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SOILS OF THE OTWAY RANGES AND SURROUNDING COASTAL PLAIN

By A. Pitt*

INTRODUCTION

The information presented in this paper has been collected by the Soil Conservation Authority of Victoria during a land system survey of the catchments of the Gellibrand River, Barwon River downstream from Winchelsea, Thompsons Creek and the numerous smaller catchments on the south side of the ranges. The part of these catchments which lies inside the area of the Otway Region as defined for the Symposium forms the present area of study (Fig. 1). Work is still in progress on this survey and this paper presents an interim report on the soils.

Previous published discussions of the soils of the area are confined to two reports: by Skene (1957) and Walbran (1971). Generalised maps of the soils have been published by CSIRO (Northcote 1960, 1962).

The distribution of the major soil groups is described in terms of land zones (Fig. 2). Land zones are groups of similar land systems (Gibbons & Downes, 1964). For each land zone, the major soil groups identified in the field are classified in descriptive terms and discussed according to their profile characteristics, possible genesis, indigenous vegetation and their significant attributes for land use (Table 1). Alternative soil classifications by Northcote (1974) and Stace et al. (1968) are included for comparison (Table 1).

There are also many soil groups of only minor occurrence. Three of these groups assume relatively high importance despite their restricted occurrence, because of their intensive use for agriculture and, in one case, for recreation. These three soil groups are discussed briefly, according to their profile characteristics and land use (Table 1).

MAJOR SOIL GROUPS

Zone 1

This zone covers the area of Lower Cretaceous sediments. The topography consists mainly of steep hills with a few restricted remnants of an undulating peneplain on the crests of these hills. The soils fall into three groups:

Dark yellowish brown gradational soils: These are found in the rainfall range 1000-2000 mm in most topographic positions including broad crests and steep slopes. The equivalent soil group from Stace et al. (1968) is the brown podzolic soils and they key out as Gn 3.94 in Northcote's factual key (1974).

They are well structured and medium to heavily textured, grading from a loam or clay loam at the surface to a silty clay or clay in the subsoil. Colluvial rock is common throughout the profile and the subsoil overlies freshly weathering sandstones and mudstones at about 1 m depth. From the limited chemical analyses available (Leslie, pers. comm.) the soil reaction is quite acid with the pH grading from about 4.5 at the surface to about 5.0 in the subsoil. Fertility appears to be comparatively high for Australian soils. Edwards and Baker (1942) have shown the Lower Cretaceous sediments to contain moderate levels of most elements essential for plant growth. Most of the soil profiles are too young for extensive leaching to have occurred, so concentration of these nutrients at the surface by root absorption and litter decay have resulted in this moderately high fertility.

These soils support some of the tallest and most productive forests in Victoria, a good indication of their natural fertility. The main species are mountain ash (*Eucalyptus regnans*), mountain grey gum (*E. cypellocarpa*), blue gum (*E. globulus*) and messmate (*E. obliqua*). The first three of these are almost completely confined to the soils of the Lower Cretaceous sediments in this part of Victoria.

The main limitation to the productive potential is the precipitous topography: many areas are too steep for mechanical equipment to operate. Where the soils occur on flatter areas such as on the remnants of the uplifted peneplain around Beech Forest and Wyelangta, their productive potential is very high. High acidity of these soils presents problems in establishing produc-

*Victorian Soil Conservation Authority, 378 Cotham Road, Kew, Victoria, 3101.

TABLE 1

Land Zone	*Soil Group*	*Stace et al. (1968)*	*Northcote (1974)*	*Vegetarian Structure Specht (1972)*	*Important Attributes for Land Use*
1	Dark Yellowish Brown Gradational Soils	Brown Podzolic Soils	Gn 3.94	Tall Open Forest	Prone to Landslips, Highly Acidic, Often Found on Very Steep Slopes
	Friable Brown Gradational Soils	Brown Podzolic Soils	Gn 4.31	Tall Open Forest	Highly Acidic
	Yellowish Brown Duplex Soils	Yellow Podzolic Soils	Db 3.31	Open Forest	Acidic, Low Water Holding Capacity, High Erosion Hazard
2	Deep Leached Sands with Coffee Rock	Podzols, Humus Podzols	Uc 2.36	Low Woodland, Closed Heath	Low Levels of Most Plant Nutrients, Moisture Stress, Sheet Erosion
	Sandy Yellow Gradational Soils	Yellow Podzolic Soils	Gn 3.84	Open Forest, Woodland	Some Nutrient Deficiencies, Sheet Erosion
3	Mottled Duplex Soils with Ironstone	Lateritic Podzolic Soils	Dr 3.31	Open Forest	Nutrient Deficiencies
	Yellow Sodic Duplex Soils with Coarse Structured Subsoils	Gleyed Podzolic Soils	Dy 3.41	Open Forest	Soil Salting (for Water Supply) Some Nutrient Deficiencies, Landslips, Gully and Sheet Erosion
Minor Soil Groups	Calcareous Sands	Calcareous Sands	Uc 1.11	Open Grassland	Vegetation Unstable — Wind Erosion
	Grey Gradational Soils	—	Gn 2.92	Open Woodland	Highly Productive
	Reddish Brown Gradational Soils	Terra Rossa	Gc 2.21	Open Woodland	Production of Crops Dependent on Free Lime in the Soil, Example — Grapes

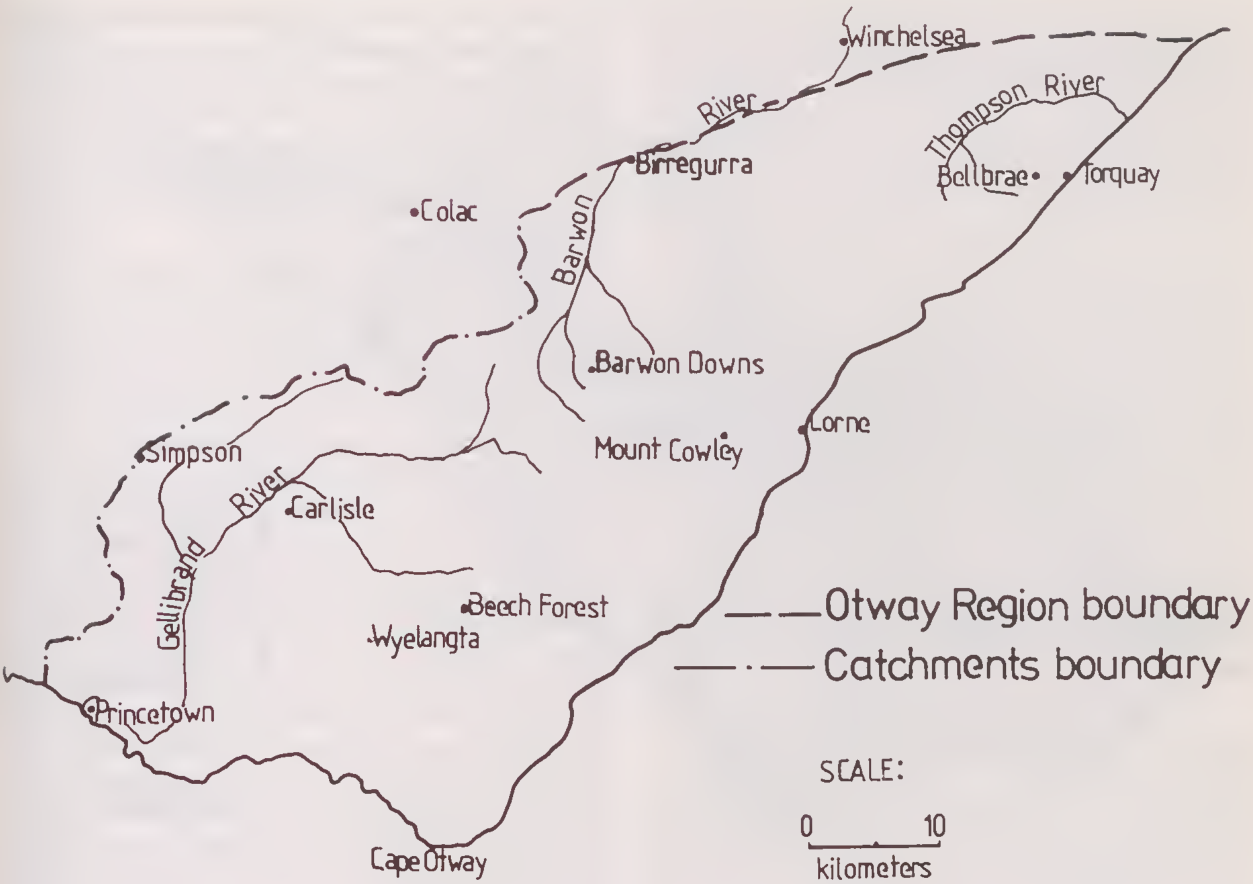

FIG. 1—The Study Area

tive pastures of introduced grasses. The ability of deep-rooted forest vegetation to extract nutrients from freshly weathering rock may give hardwood and softwood forestry a potential advantage over agricultural uses of the land. The other major form of land use on these soils is water supply and here the high organic content of the surface layers of the soil is important in aiding retention of large quantities of water during rainstorms and then slowly releasing it to streams during subsequent dry periods. Loss of these surface layers of soil leads to a loss of the degree of perenniality of streams.

Landslides, slumping and sheet erosion are the major forms of soil deterioration to be contended with. Both landslides and sheet erosion occur under natural conditions but appear to increase in incidence following clearing of the native timber.

Road batters around the Great Ocean Road are very prone to slumping. Proximity to the sea and exposure to on-shore salt-laden winds has most probably resulted in replacement of the adsorption sites on the clay with sodium ions. This leads to a decreased attraction of the clay particles and increases the proneness of the clay to dispersion and hence to rilling and slumping of the road batters.

Friable brown gradational soils: Outlying remnants of the uplifted peneplain around Mt. Cowley still have the yellow gradational soils (above) as the dominant soil group, but also have very deeply weathered friable brown gradational soils as a sub-dominant group. They are also referred to as brown mountain soils or acid brown earths and key out to Gn 4.31 from Northcote (1974).

Most commonly the profile consists of a black loam or clay loam overlying a brown light clay at 60 cm. The light clay continues to about 2 m before weathered sandstones are encountered. Their occurrence is probably due to a change in the nature of the parent material but the mineralogical and chemical differences of the rocks have not been determined.

The depth of the soils indicates that these geological beds are more prone to weathering than those where the dark yellowish brown gradational soils are found.

Major forms of land use on these soils are hardwood

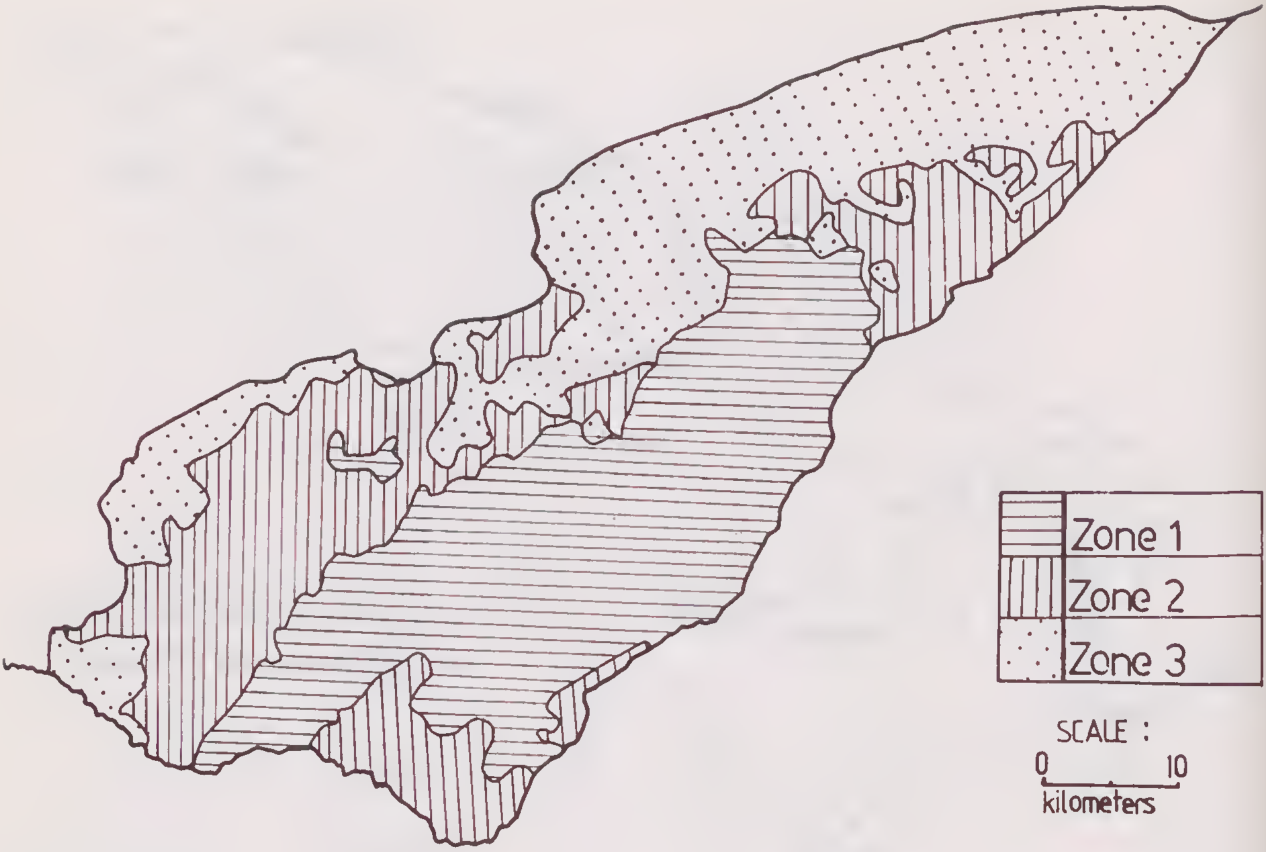

FIG. 2—Land Zones

forestry and water supply. The high organic content and depth of the soil makes them well suited to these uses.

Yellowish-brown duplex soils: Also known as yellow podzolic soils according to Stace et al. (1968) and as Db 3.31 from Northcote (1974) these soils are found in those parts of the Ranges where rainfall is less than 1000 mm per annum.

The surface texture is commonly a loam and this is underlain by a weakly bleached A_2 horizon of similar texture and weak structure. At about 40 cm there is a comparatively sharp change to a yellow silty clay frequently interspersed with weathering sandstones. Thus these soils have duplex profiles, that is, a marked and sudden texture contrast between the A and the B horizons.

Open forests of messmate (*E. obliqua*), narrow leaf peppermint (*E. radiata*) and blue gum (*E. globulus*) are the major vegetative associations. Both forestry and agricultural potential are lower than in the abovementioned areas because of the lower annual rainfall. Water supply potential is also lower, and this is partly due to the influence of the duplex profile. The sharp decrease in permeability across the A/B horizon boundary tends to produce rapid overland or subsurface flow. Thus the amount of water retained for slower release to streams is reduced.

The duplex profile has other influences on the potential uses of these soils. For example, pines have difficulty growing where there is a water-impeding layer within 50 cm of the surface, as is often the case in duplex soils. Also some forms of erosion such as gullying and tunnelling are more likely to occur on duplex soils.

ZONE 2

Surrounding the Lower Cretaceous sediments on all but the seaward side are the unconsolidated sediments of the Dillwyn Formation. Here the soils are extremely variable, their profile characteristics depending to a large extent on the proportions of sand and clay in the parent material. Thus, many different soil groups occur and only the two major groups are discussed:

Deep leached sands with coffee rock: These soils are common on the immediate periphery of the Lower Cretaceous sediments towards Carlisle and also in the north-east near Anglesea. Their classification from Northcote's (1974) key is Uc 2.36 and they belong to both the podzols and the humic podzols of Stace et al. (1968).

The soils have a dark A_1 horizon high in organic matter, a bleached, almost white A_2 horizon, a cemented and often impermeable horizon of coffee rock at about 50 cm, frequently with ferruginous nodules inside a cemented mass, and then a structureless coarse clayey sand horizon.

The soils of this group have very low levels of most plant nutrients and this is reflected by the stunted nature of the vegetation with its structure ranging from low woodlands to heathlands. The structure seems to be also determined by the moisture regime of the soils. In areas where the coffee-rock is discontinuous or found to exist in columns, the soils are more permeable and low woodlands of narrow-leaf peppermint (*E. radiata*), shining peppermint (*E. nitida*) and brown stringybark (*E. baxteri*) dominate. However when the coffee-rock is thick and continuous the soils are badly drained, with seasonal perched water-tables. In these areas heathlands and low open woodlands of shining peppermint (*E. nitida*), prickly tea-tree (*Leptospermum juniperinum*) and scented paperbark (*Melaleuca squarrosa*) are most common. Thus it appears that some eucalypts can survive the low level of fertility and extreme moisture stresses found on the well drained soils but when these conditions are combined with waterlogging in winter, only heathland vegetation can develop. A further development of this effect is the increase in the occurrence of heathland vegetation with increasing rainfall: soils with intermediate permeability become more extensively waterlogged as one moves closer to the ranges and the rainfall increases.

Sandy yellow gradational soils: Where the parent material has at least a moderate amount of clay, these soils tend to develop. They are classified as Gn 3.84 from Northcote (1974) and as yellow podzolic soils from Stace et al. (1968).

Typically shallow light-textured A_1 and A_2 horizons overlie a yellow sandy clay loam horizon at about 25 cm. This horizon may or may not contain ferruginous nodules and usually continues to about 75 cm. Beneath this horizon is a strongly structured clay or silty clay with shiny ped faces and yellow, grey and occasionally red mottles.

In most areas, varying depths of iron-rich sands have been washed over the top of the soil profiles, apparently in previous drier climatic periods. The thickness of these sand sheets varies from a few centimetres to many metres, but in most places it seems to be about 40 cm thick. During subsequent weathering and leaching, the iron has been washed out of the surface horizons of sand into the top of the older soil profile, usually the yellow sandy clay loam horizon. This has led to cementation and formation of large areas of coffee rock.

Permeability is quite variable depending on the extent of development of the coffee rock. This is reflected in the native vegetation: open forests of messmate (*E. obliqua*) and brown stringybark (*E. baxteri*), dominated by the former, are found on the more permeable soils without coffee rock. These are replaced by woodlands of brown stringybark (*E. baxteri*) and narrow-leaf peppermint (*E. radiata*) as the coffee rock develops underneath the sand sheets, resulting in impeded drainage.

Sheet erosion by water and possibly by wind can be a problem on these sandy, weak structured soils. Damage can be severe on areas clear of vegetation. Other forms of soil deterioration are not as important.

Zone 3

Further away from the Ranges again are exposures of the more clayey Tertiary sediments known as the Gellibrand Marl which roughly coincide with the third land zone. This area is widely used for agriculture. There are two major soil groups to be found:

Mottled duplex soils with ironstone: Classified as Dr 3.31 from Northcote (1974) and as a variation of the lateritic podzolic soils from Stace et al. (1968), these soils are found on flat or very gentle plateau remnants over most of this area.

Surface textures are loams, frequently with an organic A_1 and a bleached A_2 horizon changing fairly sharply to a silty clay at about 40 cm. This clay has an extremely strong structure and is dominated by red and white mottles on shiny angular peds. This horizon is underlain by large ferruginous concretions or a continuous indurated horizon at about one m. Typical mottled zones and pallid zones commonly found in most lateritic profiles in Victoria are usually present.

In places the strong structured clay horizon continues to greater depths with only minor iron cementation and directly overlies the clayey marls of the parent material. These sediments are also deeply weathered and strongly kaolinised.

These soils are thought to have been formed during a previous climate, when conditions were conducive to the synthesis of lateritic soils. They have survived subsequent erosional cycles to remain as lateritic soils today with only minor modifications.

Most of the native forests have been cleared for agriculture, some areas just recently for the Heytesbury settlement around Simpson. They originally supported open forests with the major species being messmate (*E. obliqua*) and swamp gum (*E. ovata*). Plant nutrient levels are commonly low with deficiencies in phosphorous, potassium, copper and molybdenum common (Phillips, pers. comm.). Intensive leaching during formation and subsequent fixation by adsorption onto sesquioxides could be the main factor responsible for these deficiencies.

Yellow sodic duplex soils with coarse structured subsoils: These soils have developed where stream dissection has cut deeply into the ancient plateaux exposing the lower lateritic horizons and Tertiary unconsolidated marls and clays. These are classified as Dy 3.41 from Northcote (1974) and belong to the gleyed podzolic soils of Stace et al. (1968).

The surface horizon is usually a loam with a dark A_1 and a bleached A_2 horizon and this sharply overlies a pale yellow (or off-white if developed on the pallid zone) heavy clay. Mottles are common in this clay horizon but are relatively dull and the structure comprises large coarse blocky peds frequently 10 cm across. These clays are quite dispersible and are probably sodic.

In some areas, such as between Barwon Downs and Winchelsea, dissection of the plateaux has been only minor. However, where dissection has been deep and extensive, for example just to the south of Birregurra, severe salting and gullying have led to widespread deterioration of the productive potential of the land. Other regions of Australia which have an almost identical catenary relationship between the soils have similar problems. The Dundas Tablelands in Victoria (Gibbons & Downes 1964) and the Darling Ranges in Western Australia (Dimmock et al. 1974) are two examples. It is postulated that the underlying pallid zones of the lateritic profile contain relatively high proportions of salt, most probably of cyclic origin. When the native vegetation is cleared the rising groundwater table and increased activity of springs brings this salt to the surface.

In the Heytesbury settlement, dissection of the lateritic plateaux has again been extensive. However most of the land has only just recently been cleared and insufficient time has elapsed for these problems to fully develop. As the severity of salting is generally observed to decrease with increasing annual rainfall, particularly when this is above 650 mm, it is anticipated that salting problems will not be as severe here as near Birregurra. However, leaching of salt from the landscape may have important consequences for proposals to use parts of the Heytesbury district for domestic water supply.

MINOR SOIL GROUPS

Three other soil groups of minor occurrence are worthy of mention because of their importance for land use.

Calcareous sands: Found on recently formed sand dunes at the river mouths and on other parts of the coastline, these soils are classified as Uc 1.11 from Northcote (1960).

The soil profile is usually an undifferentiated mixture of sand and weathering shell particles. There is sometimes a slight darkening near the surface due to organic matter build-up. The indigenous vegetation is a grassland of hairy spinifex (*Spinifex hirsutus*) but this is extremely susceptible to trampling from people travelling over the dunes and it has completely disappeared from many of the dunes in the area. When bare of vegetation these dunes are highly susceptible to wind erosion, and it is often necessary to stabilise them by hand planting the introduced marram grass (*Ammophila arenaria*) which is more tolerant of trampling.

Further inland on older dunes these calcareous sands give way to more leached siliceous sands with a woodland vegetation which is more tolerant to trampling and disturbance.

Grey gradational soils: Classified most often as Gn 2.92 from Northcote (1974), these soils exhibit wide degrees of variation. They are found on alluvial flats throughout the area, and are noted for their productive capacity, particularly around Carlisle and Barwon Downs.

Profiles are quite variable as mentioned, but generally have a deep sandy loam topsoil rich in organic matter merging gradually into a light coloured sandy clay loam or sandy clay. The soils are quite porous, well drained and fertile.

Reddish brown gradational soils: These soils are found on the well drained slopes where limestone is outcropping, as at Bellbrae in the north east of the area. They are known as Terra Rossa's from Stace et al. (1968) and are classified as Gn 2.21 from Northcote (1974).

Textures are usually clay loams or light clays grading to medium clays with depth. Weathering limestone is found at about 60 cm to 1 m below the surface. Their structure is strong and these soils are quite stable to most forms of erosion. Fertility is relatively high.

They are also highly productive agriculturally and where they occur are intensively used for grazing and cropping.

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